

APPLICATION FOR UNITED STATES LETTERS PATENT

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TITLE: METHOD OF PROCESSING X-RAY IMAGES

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CROSS REFERENCE TO RELATED APPLICATION

This application claims the priority of German

- 5 Application No. 199 16 664.1 filed April 14, 1999, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 This invention relates to a method of processing X-ray images. Articles contained in a transilluminated object are made visible to an operator/observer on a monitor and markings are placed around earlier-defined articles.

15 ~~To facilitate the evaluation of an X-ray image of~~
~~transilluminated objects for an observer, the X-ray image~~
~~is automatically examined in the X-ray system based on~~
~~various properties. In such an arrangement a software is~~
~~searching in the transilluminated object for certain~~
20 ~~previously defined articles such as firearms, piercing~~
~~weapons or explosives.~~

~~A method of the above-outlined type is described in~~
~~German Patent document 198 55 250.5. If such an article is~~

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detected, the observer receives information that the article has to be more thoroughly investigated in the transilluminated object. Such an information is the marking of the discovered article on the monitor, for example, by drawing a circle or frame therearound. Since the detected articles are not recognized as a whole, about each detected article a marking is placed. An evaluation by the observer is made difficult if a plurality of such markings appear on the monitor. Such an event is of significant disadvantage for the observer if the run-through period is, for example, approximately 6 seconds.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved method of processing an X-ray image in which the placed markings are optimized to facilitate the evaluation of an X-ray image for the observer.

This object and others to become apparent as the specification progresses, are accomplished by the invention, according to which, briefly stated, the method of processing an X-ray image of articles contained in a transilluminated object and made visible for an observer on

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a monitor screen, includes the following steps: Placing individual markings about the image of certain, previously determined articles and automatically and stepwise combining the individual markings into a final added marking if at least two individual markings mutually fit.

5 The combining step includes the steps of comparing for fit mutually facing sides of two adjoining individual markings and determining a ratio of an overlapping area of the two adjoining individual markings to the total area of at least 10 one of the two adjoining individual markings.

The invention is based on the principle to automatically couple to one another the numerous visible markings, so that on the monitor only a single marking as the sum of the individual markings appears to thus provide 15 for the observer a central marking to make possible a rapid and reliable evaluation concerning the article in the transilluminated object. The coupling of the markings is effected by a function which is inputted in the X-ray system and which combines the mutually fitting markings and 20 places a combined marking into the X-ray image. Only markings which belong to one another are combined. Whether two markings belong to one another is determined by their spatial proximity and their overlap.

According to an advantageous feature of the invention, joined markings may again be removed, for example, when the operator wishes to see the markings individually. Also, the extent of the combination of the markings may be adjusted. As a result, the markings may be shown unchanged or combined. Further, intermediate steps are possible in which case then maximum 2, 3, 3, 5, etc. markings may be coupled to one another, so that on the monitor two to three markings, etc. may be made visible as individual added markings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a simplified schematic illustration of an X-ray system adapted to perform the method according to the invention.

Figure 2 is a block diagram of a computer system in an X-ray system for performing the method according to the invention.

Figures 3a, 3b and 3c are visual representations for providing a common marking on the monitor.

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Figures 4a, 4b and 4c are visual representations of the method for removing the common marking from the monitor.

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DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 illustrates an X-ray system having a conventional X-ray generator 1 and a detector 2, between which an object 3 to be transilluminated is positioned.

10 The object 3 may be a piece of luggage in which various articles 4, 5, 6 are contained. Non-illustrated known components couple a computer system 7 with the detector 2. The measuring results are made visible on a monitor 8 and/or a printer 9 coupled to the computer system 7.

15 Figure 2 illustrates the essential component groups of the computer system 7 for performing the method according to the invention. The output of the detector 2 is connected with an image processing device 10 which is, in turn, connected with a marking memory 11 and a memory 12 for the marking lists. The marking memory 11 is bi-directionally connected with the memory 12 and thus gains access to the marking list accumulated during the process. The marking memory 11 is provided with a sub-marking memory

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11.1 which will be described in more detail as the specification progresses.

The method according to the invention is performed as follows:

- 5 The X-ray generator 1 directs an X-ray beam FX1 to the object 3 to be transilluminated. The X-ray beam FX1 is weakened by the respective absorption behavior of the articles 4, 5, 6 in the object 3 as well as by the housing material of the object 3 and is received by the detector 2.
- 10 The detector 2, for example, a line camera formed of a plurality of X-ray detectors, produces signals from the non-absorbed part of the X-ray beam and applies the signals, as image data information about the transilluminated object 3, to the computer system 7 for image processing. Such an inputting is performed preferably line-by-line and in a continuous manner. The image data are evaluated in a known manner in the image processing device 10 and are readied for a visual representation on a monitor. An X-ray image represented in this manner is composed of image dots having various properties, for example, a gray scale and material value from which the article 4, 5, 6 may be recognized.
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- 20

In principle, about each detected article defined as dangerous, for example articles 4, 5, 6, automatically a respective separate individual marking M1, M2, M3 is placed, as shown in Figure 3a. Thus, about the first-
5 recognized article 4 the marking M1 and about the second-recognized article 5 a marking M2 is placed. Already at this point the two markings M1, M2 are compared with one another by means of a function to determine whether the two markings M1 and M2 fit to one another. For this purpose
10 the mutually fitting or mutually facing sides of the markings M1 and M2 are compared by means of coordinate comparison. The more these sides correspond to one another in position and length, the better their fit. The distance between the individual markings M1 and M2 must not exceed a
15 previously set, variable limit value.

In the present illustration the individual markings M1 and M2 are situated too far from one another so that no common marking is established. Both markings M1 and M2 are inputted into the list memory 12 as well as the sub-marking
20 memory 11.1 of the marking memory 11.

Approximately at the same time the detection of the article 6 and placing the marking M3 thereabout occur. In a further step the marking M3 is compared with the marking

M₁, that is, it is determined whether the individual markings M₁ and M₃ mutually fit. Since both markings M₁ and M₃ overlap on the fitting sides, additionally the ratio of the common (overlapping) surfaces of the two markings M₁ and M₃ to the surface of the smaller of the two markings M₁ and M₃ is determined for verifying the mutually fitting sides. The greater the ratio the better the mutual fit of the markings M₁ and M₃. As shown in Figure 3b, the markings M₁ and M₃ are replaced by a new marking as an individual added marking M_{1/3} in which the respective outer sides of the markings M₁ and M₃ yield the size of the new individual added marking M_{1/3}. To ensure that the individual markings M₁ and M₃ are not lost in the computer system, they are stored in the sub-marking memory 11.1 as sub-markings M₁ and M₃ of the individual added marking M_{1/3}.

Approximately at the same time, the new individual added marking M_{1/3} is compared for correspondence with the individual marking M₂ from the marking list. As a result of such a comparison, a new marking M_g as a final added marking is applied to the monitor 8. As shown in Figure 3c, the articles 4, 5 and 7 are found within the final added marking M_g. The individual marking M₂ and the

individual added marking M1/3 become sub-markings of the final added marking Mg. Thus, for the observer there is obtained a well ascertainable X-ray image on the monitor 8 on which advantageously only a single final added marking 5 Mg is shown without, however, losing the relationships between the individual markings M1, M2, M3 and the representation of the final added marking Mg on the monitor 8.

The information concerning the individual markings M1, 10 M2, M3 as well as their assignment as sub-markings in relation to the individual added marking M1/3 and the final added marking Mg remain in the computer system 7 in the memory 12 as well as in the sub-marking memory 11.1. This makes it possible to again separately display, upon 15 extinguishing the final added marking Mg, all sub-markings M1 and M3 of the individual added marking M1/3 as well as the sub-marking M2. For this purpose the final added marking Mg is removed by the operator from the monitor 8, for example, by pushbutton operation, whereupon the 20 computer system 7 again renders visible the individual stored markings M1, M2 (M3 is not shown) on the monitor 8, as shown in Figures 4a, 4b and 4c.

Such necessary information is taken in steps from the sub-marking memory 11.1 as well as from the marking list in the memory 12. The computer system 7 proceeds with the earlier-described steps in a reverse order. First it is

5 determined which final added marking Mg was removed and the sub-marking memory 11.1 is searched for the individual, associated sub-markings. In this proceeding the sub-marking M1/3 belonging to the final added marking Mg as well as the sub-marking M2 are found. The final added

10 marking Mg is extinguished in the marking list and the sub-marking M1/3 found in the sub-marking memory 11.1 and the sub-marking M2 are added to the marking list of the memory 12. Further, by means of the software of the computer system 7 it is recognized that the sub-marking M1/3, as an

15 individual added marking, is composed of the markings M1 and M3, while the sub-marking M2 has no further sub-markings and thus represents an individual marking. In the marking list the individual added marking M1/3 is extinguished and replaced by the sub-markings M1 and M3

20 which are then inputted from the sub-marking memory 11.1 in the memory 12. The individual markings M1, M2 and M3 are applied to the monitor 8 from the marking list and displayed thereon. In this manner the observer may decide

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whether the common marking Mg or the sub-markings/individual markings M1/3, M2 or only the individual markings M1, M2, M3, etc. should be shown on the monitor 8.

5 It is to be understood that upon detection of several articles, that is, more than the mentioned three articles 4, 5 and 6 the set markings M1, M2 and M3, etc. are compared with one another as long as no mutually fitting markings (individual added markings) are found.

10 Several variants are feasible within the scope of the invention. Thus, the degree and combination of the marking may be set. With such a setting it may be achieved that the markings are not always combined or are only partially combined, that is, intermediate steps with respect to the 15 degree of combination are possible. In this manner too, individual markings may be removed from the combined markings which will thus decompose into several parts.

It will be understood that the above description of the present invention is susceptible to various 20 modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.